Macroeconomic regimes

July 2023

Frontier Advisors

About us

Frontier has been at the forefront of institutional investment advice in Australia for over 25 years and provides advice on over $600 billion of assets across the superannuation, charity, public sector, insurance and university sectors.

Frontier's purpose is to empower our clients to advance prosperity for their beneficiaries through knowledge sharing, customisation, technology solutions and an alignment and focus unconstrained by product or manager conflict.

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Donna Davis joined Frontier Advisors as an Associate in 2019 before being promoted to Consultant in 2021. She works with the Capital Markets and Asset Allocation team, working on portfolio construction and asset class research. She has a special interest in data analysis techniques, machine learning and their applications in portfolio construction, sensitivity analysis and climate modelling. She also works with the Alternatives and Derivatives team leading research into Insurance Linked Securities.

Prior to joining Frontier, Donna worked for AustralianSuper in their Options Management Team. She also has 9 years banking experience with the Commonwealth Bank and ANZ in Corporate and Commercial Lending. Donna holds a Bachelor of Quantitative Finance from the University of South Australia and is a CFA charter holder.

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Vivian Xu joined Frontier Advisors in 2022 in the Capital Markets and Asset Allocation Team. Her role focuses on quantitative analysis and macro economic analysis. Vivian is pursuing a PhD in Finance from the University of Melbourne. Her research interest covers mutual fund management, corporate finance and emerging markets. Vivian has published articles in top ranking peer-reviewed journals.

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Huan joined Frontier Advisors as a Quantitative Developer in March 2021. Huan is responsible for research and development of quantitative solutions within the Technology team. Prior to joining Frontier, Huan was a Research Analyst in Kaiser Trading Group (KTG) where he was focused on developing Automatic Execution Systems and intra-day trading strategies. Before KTG, Huan worked as a research academic at The University of Melbourne and Deakin University after he obtained his PhD in System Engineering from The Australian National University.

Huan holds a B.Sc. and M.Sc. degree from Northeastern University, China, majoring in Applied Mathematics.

INTRODUCTION

Portfolio modelling under different macro regimes

Market experience has shown that economic conditions are constantly changing. This work seeks to better reflect a diverse range of economic environments or regimes to allow for more nuanced portfolio modelling by examining how asset returns behave differently under different macro environments as well as the effect of macro environments on modelling portfolio outcomes.

In this paper we introduce a set of pre-defined regimes of inflation and GDP growth and introduce a new portfolio modelling approach that utilises regime pathways and Monte Carlo simulations.

The analysis of economic regimes is particularly important for investors, as it can help them identify which asset classes are likely to perform well under different economic conditions. The analytical framework based on regimes holds significant potential for a wide array of applications, including future analysis, historical review, and forward projection scenarios.

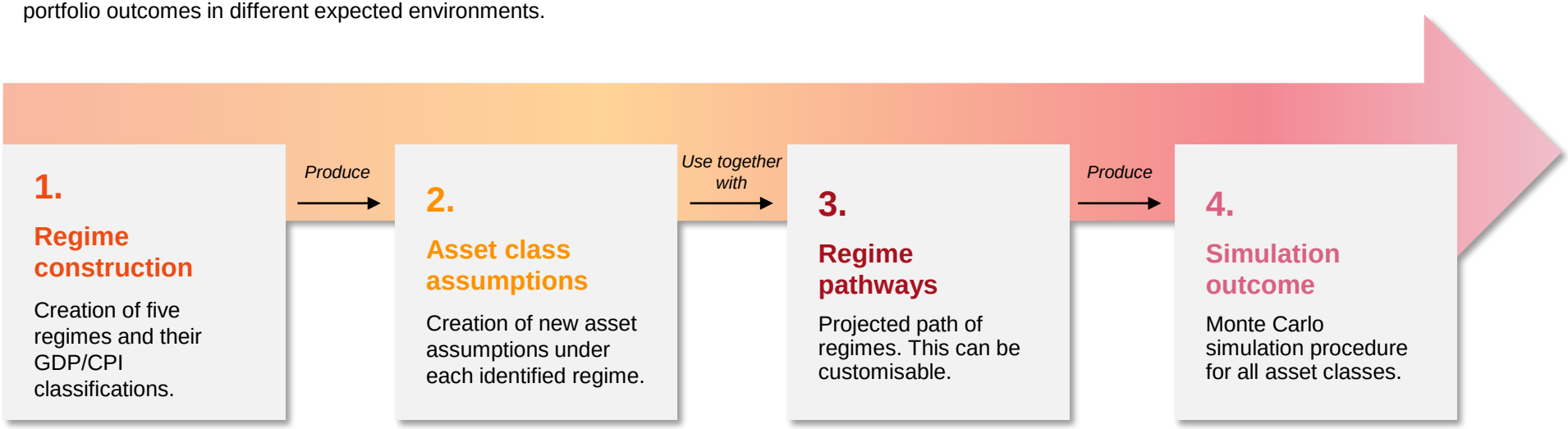
Economic regimes

Categorising the economic environment

Economic regime analysis is a vital tool for investors, enabling them to enhance portfolio construction and effectively manage risks by understanding how various asset classes behave in different macroeconomic conditions.

An economic regime is defined as a particular state or category of the economic environment. Once defined, these regimes can be used to provide insights into other key portfolio elements such as asset class assumptions, potential future economic paths and simulated portfolio outcomes. This paper covers four areas of regime analysis:

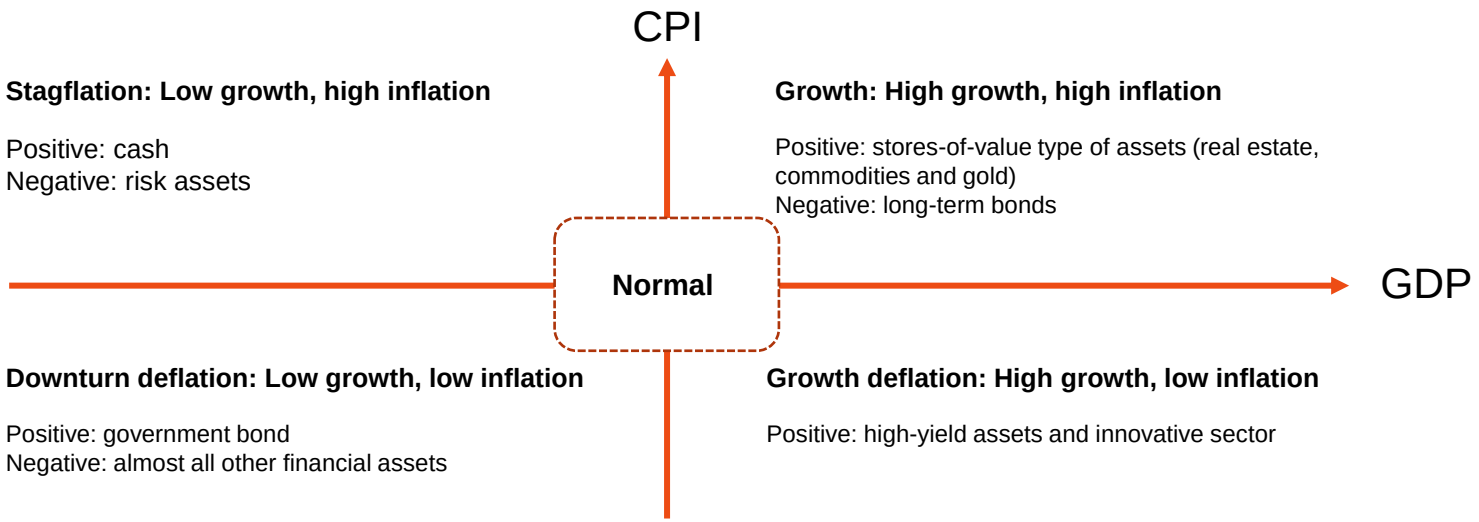
- **Regime classification.** Regimes are classified by growth/inflation cut-off points based on historic analysis. The majority of economic environments can be captured by five regime categories: *Normal, Growth, Growth deflation, Downturn deflation and Stagflation*. To form the classifications, we collectively considered the descriptive statistics and correlation of asset returns under each regime.
- **Asset assumptions by regimes.** Asset distribution assumptions including return, risk and correlation which are tailored to each identified regime.
- **Regime pathways.** Combining multiple regimes to better understand potential future paths of the economic environment.
- **Portfolio modelling.** Portfolio simulation utilising Monte Carlo simulations in conjunction with regime pathways to compare a range of different potential portfolio outcomes in different expected environments.



Regime classification

Regime classification

Five pre-defined regimes cover the majority of potential economic environments

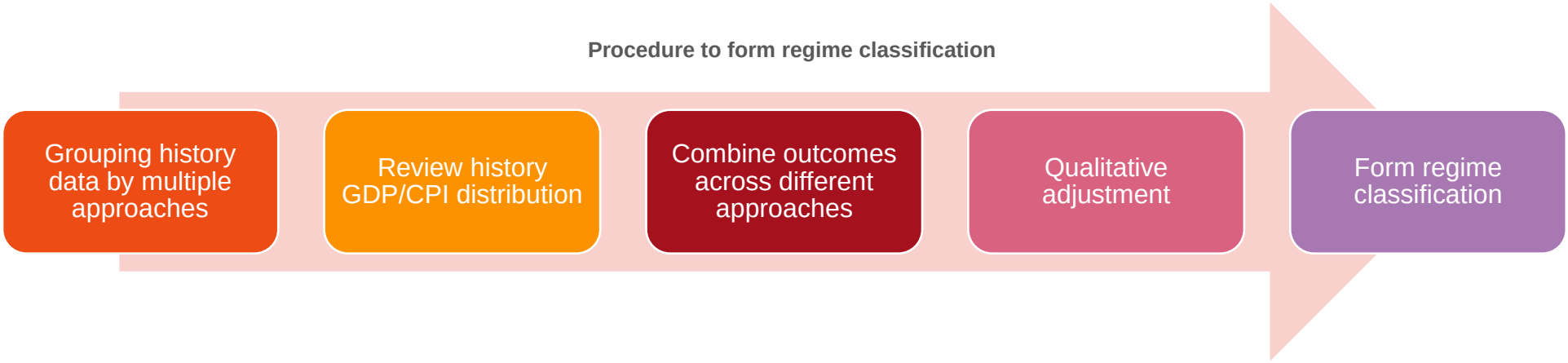


Starting from a classic growth-inflation quadrant analytical framework, we defined five regimes based on GDP/CPI cut-off points. These cut-off points are set to form mutually exclusive regimes, avoiding any overlapping in boundaries.

- **Normal:** This is considered the economic regime the majority of the time, with GDP and CPI within the 'normal' ranges that broadly aligns with the historical US levels. 'Normal' represents the most likely outcome based on historical statistics. A balanced portfolio tends to do well in *Normal*.
- **Growth:** This regime incorporates periods of strong economic growth or even inflationary boom – both inflation and GDP are above the 'normal' ranges. Stores-of-value type of assets (real estate, commodities and gold) typically do well in this regime while long-term bonds tend to underperform.
- **Growth deflation:** This regime incorporates periods where growth is positive while inflation remains low. It is sometimes also described as 'Goldilocks'. High-yield assets and growth assets tend to benefit from this type of environment.
- **Downturn deflation:** This regime incorporates periods of contraction – such as recessions and depressions. In a classic recession, almost all risk assets (equities, properties and high-yield bonds) perform poorly (at least in the initial part of the downturn). Government bonds are typically the safe-haven asset.
- **Stagflation:** This regime incorporates periods where inflation is high but economic growth is low or negative. Equity tends to underperform due to growth concerns while bonds also tend to underperform because of high inflation. Cash is usually considered the safest in this type of environment.

Regime classification methodology

Quantitative analysis + qualitative overlay



We collectively evaluated the outcomes from various alternative approaches for grouping historical data to select GDP/CPI cut-off points that define a regime**.** By leveraging historical data, we investigated the descriptive statistics and correlation of asset returns under each regime. It is important to note that each approach has its own advantages and drawbacks. Regime classifications are the result of collectively considering the outcomes from these multiple methodologies combined with qualitative oversight. More details on the three approaches can be found in the Appendix.

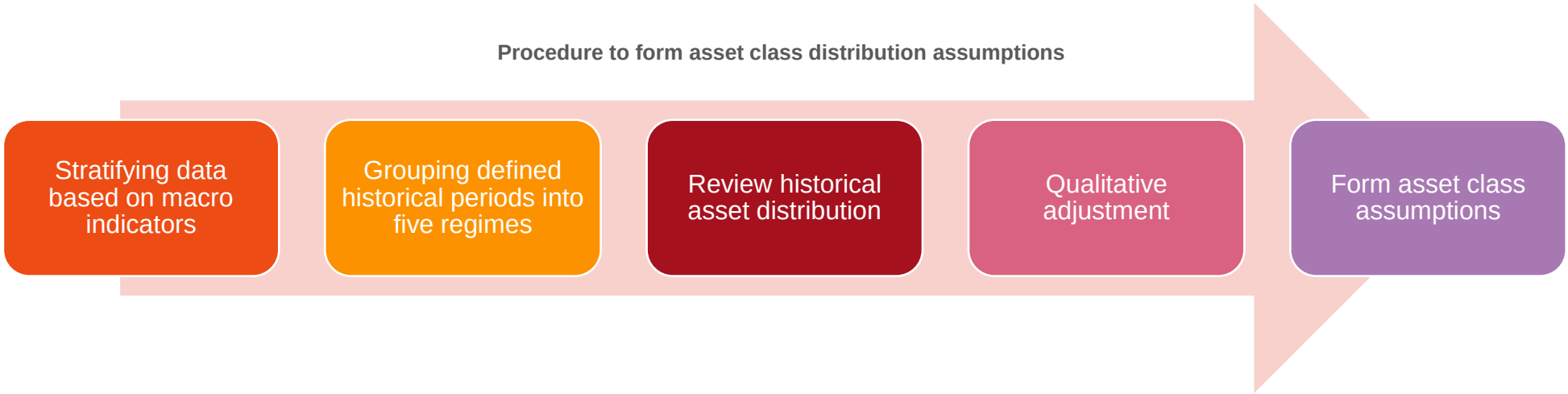
- **Approach 1 – GDP/CPI stratification:** Clustering historical data based on proximity in GDP/CPI and regimes are classified using pre-defined cut-off points. A benefit of this approach is it is clear and easy to visualise and is a direct application of the growth-inflation quadrant system. However, the drawback is it treats each historical data point as an independent observation, ignores continuity in time.
- **Approach 2 – continuous period analysis:** Qualitatively grouping consecutive historical periods based on general market cycles. This approach complements the first approach in that it features a focus on momentum or time-series correlation between consecutive periods.
- **Approach 3 – economic fundamental analysis:** Searching for historical periods which exhibit a similar macro environment by comparing economic fundamentals. One significant benefit of this approach is that it accounts for multiple macro indicators than just GDP growth and inflation.

Note: Most of our analysis has been completed leveraging US GDP and CPI values due to the longer track record. Our research highlighted a strong relationship between US and Australian values indicating US factors could be used as a satisfactory proxy for the growth and inflation defining elements. For further details, see the Appendix.

Asset class assumptions

Asset class assumptions

From regime classification to asset distribution



The asset class assumptions are formed based on the grouped historical data.

Step 1: Stratify data based on macroeconomic indicators using the GDP/CPI cut-off points from the previous regime construction process.

Step 2: Involves grouping historical periods into five regimes (e.g. January 1980 is classified as Stagflation with GDP<2% and CPI >2%).

Step 3: Calculate the historical asset distribution parameters (return, risk, correlation) of all asset classes under each regime.

Step 4: Make qualitative adjustments to the calculated parameters based on relevant factors.

Step 5: Form asset class assumptions that align with each regime.

Asset assumptions by regimes

Asset return distributions can vary greatly depending on macro environment

Chart 1: Return assumptions (% p.a.)

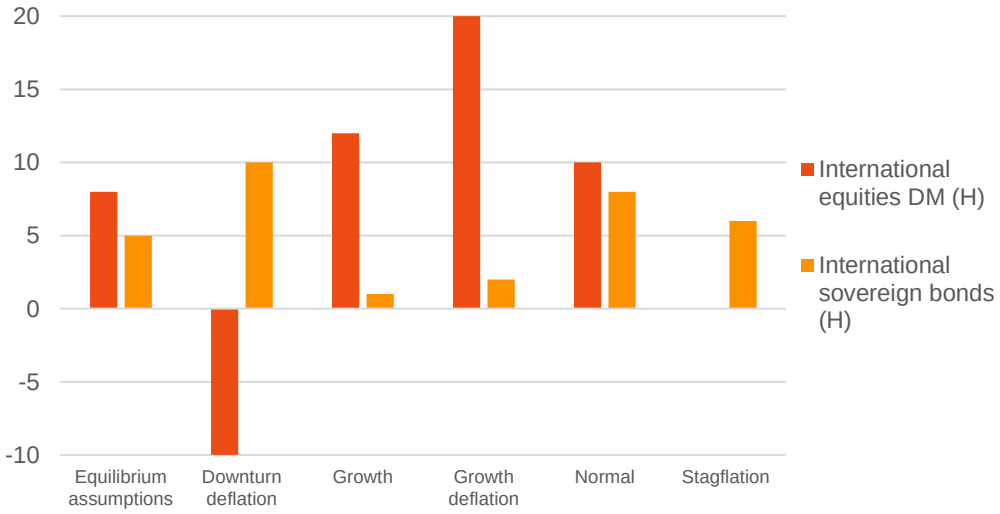
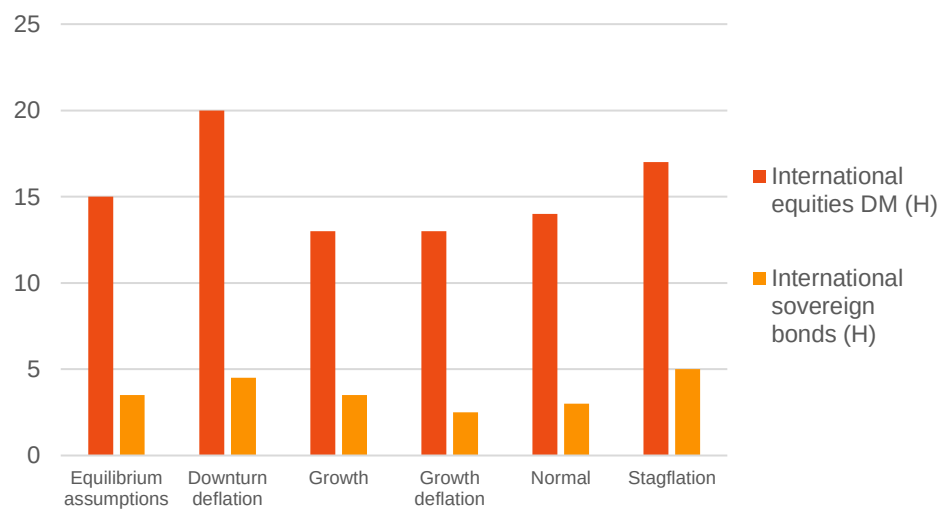


Chart 2: Risk assumptions (% p.a.)



Return, risk and correlation assumptions are based on a combination of quantitative historic data analysis and qualitative understanding of asset class returns.

Chart 1 and Chart 2 visualise the return and risk assumptions for international equities and international sovereign bonds by regimes as an example. The variation in distribution across regimes highlights:

- Equity returns are negative in *Downturn deflations* and much higher in *Growth deflation*.
- Bond returns are low in *Growth* and *Growth inflation*, higher in *Downturn deflation*. Note: bond nominal returns shown do not highlight real return differences (e.g. bond real returns in *Stagflation* are much lower compared to normal real returns).
- Bonds are negatively correlated to inflation while equities are generally positively correlated to inflation, which contributes to equity-bond correlations being negative, but in high inflation regimes equity-bond correlations are often positive.
- Compared to returns, risk remains fairly stable across regimes except having higher volatility in *Downturn deflation*.

Regime pathways

Regime pathways

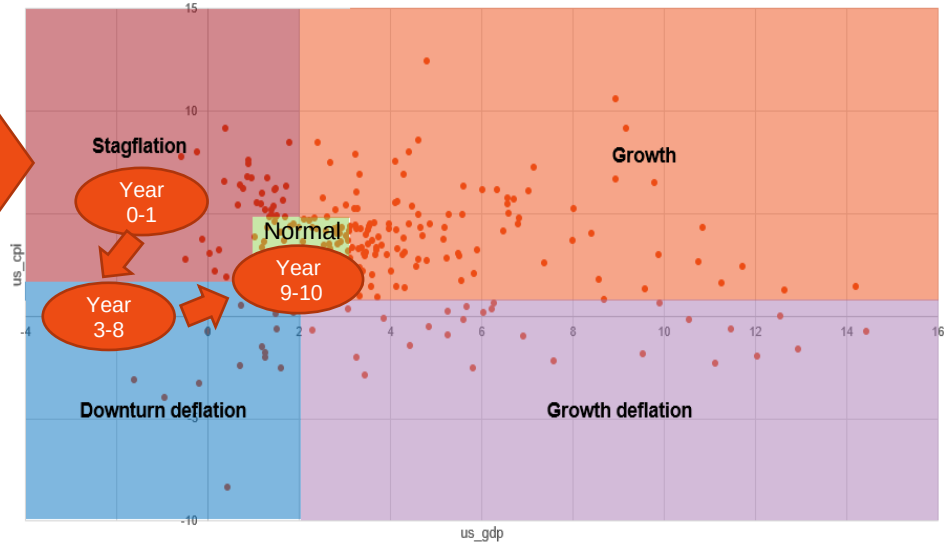
Grouping together a series of economic regimes to reflect a future expectation of the macro environment

Economic scenario

Year	1	2	3	4	5	6	7	8	9	10
CPI (%)	6.2	2.5	-1.5	-1.1	-0.6	-0.2	0.3	0.7	1.1	1.6
GDP (%)	1.5	-0.5	-2.5	-0.8	1.6	1.6	1.6	1.6	1.6	1.6
Regime	ST	ST	DD	DD	DD	DD	DD	N	N	N

Note: ST: Stagflation; DD: Downturn deflation; N: Normal. The numbers in the table are for demonstration purpose only.

Regime pathway mapped into scatterplot



A regime pathway is a way to combine a series of regimes together to create a simulation that leverages a collection of different regime assumptions through the simulation process.

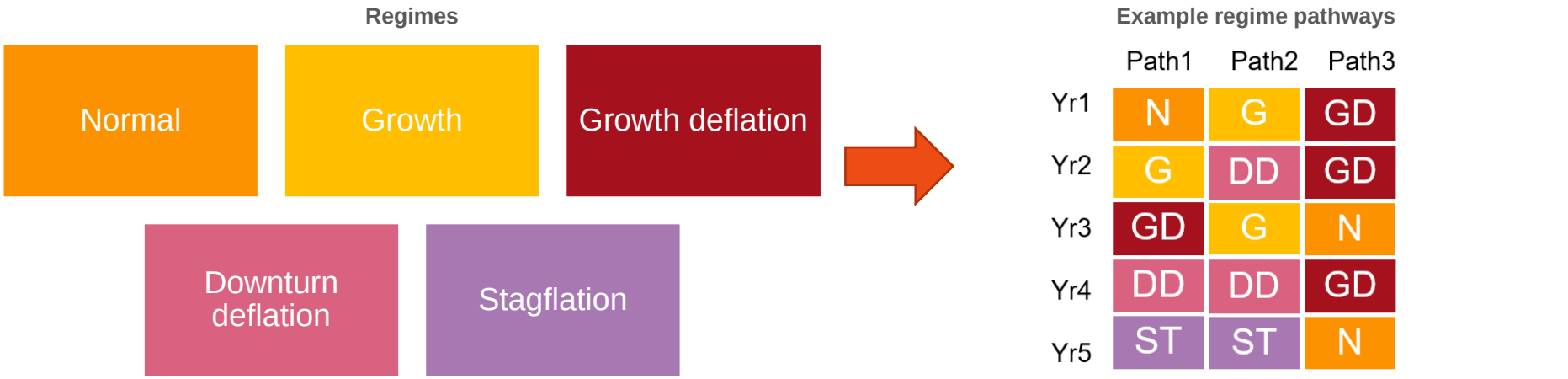
One way to create a regime pathway is based on economic projections of GDP and CPI. The projection values can be compared with the economic regime definitions to see which regime each years' forecast falls into. This then creates a 'regime pathway' which can be used to create a portfolio simulation. Frontier generates economic projections on a quarterly basis for various potential economic scenarios and these projections can provide a series of regime pathways.

As an example, a ten-year simulation based on an indicative ‘global economic downturn’ scenario would run as follows:

- The first two years of the simulation would be based on the asset class assumptions of a *Stagflation* regime.
- The next six years of the simulation would be based on the asset class assumptions of a *Downturn deflation* regime.
- The final two years of the simulation would be based on the asset class assumptions of a *Normal* regime.

Regime pathways

The five regimes can be used as building blocks for portfolio scenario modelling



Note: N=Normal, G=Growth, GD=Growth deflation, DD=Downturn deflation, ST=Stagflation

Frontier defined assumptions for growth and inflation regimes are used as the building blocks. The regime 'blocks' can be mixed-and-matched to form regime pathways for any given number of years.

- Each regime block represents a specific set of conditions or assumptions about the economic environment. By selecting and combining these blocks in various ways, users can create a multitude of potential 'regime pathways' that map out possible future scenarios over a specified time period.
- The focus of this work is to model potential outcomes in different scenarios. Users can create their own regime pathways to model how different macro environments affect portfolio outcomes.
- This method offers flexibility, customisation, and complexity in scenario creation, and it facilitates comparability between different scenarios, aiding decision-making.

Portfolio modelling

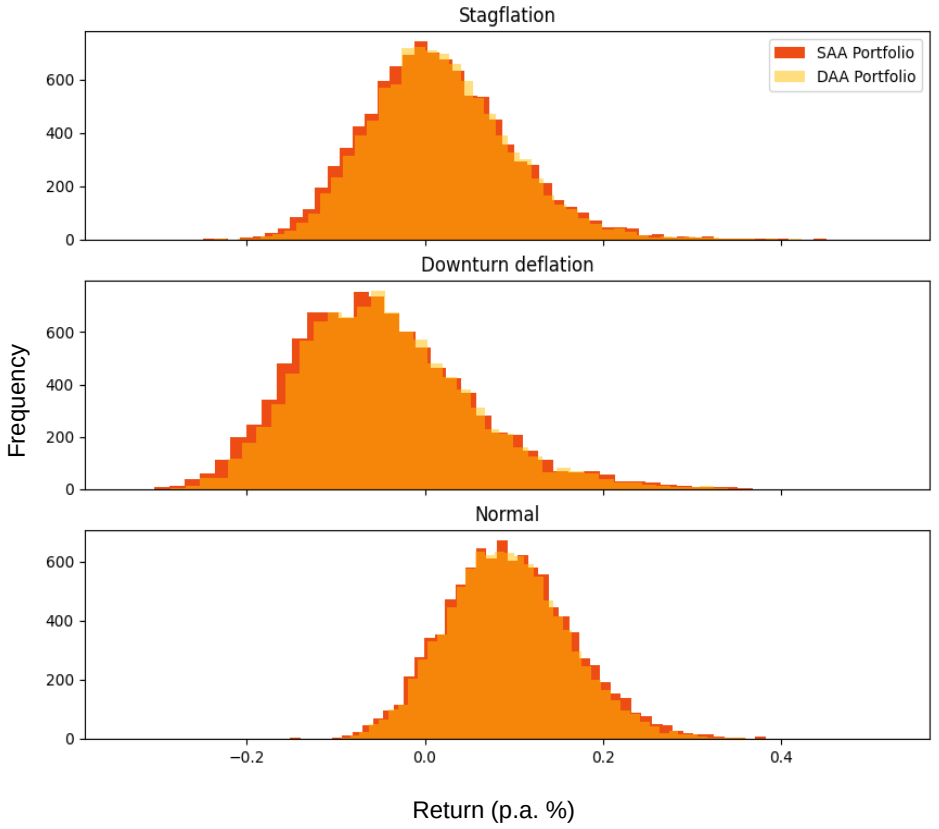
Simulation outcome

Regime pathways combined with Monte Carlo simulation to generate portfolio simulations

To incorporate regime assumptions, we leverage the existing Monte Carlo procedure to simulate CPI and GDP together with asset class returns in a correlated framework.

- Monte Carlo simulation is a computational algorithm that relies on repeated random sampling to obtain numerical results. It's a probabilistic method used to model the probability of different outcomes in a process that cannot be easily predicted due to the intervention of random variables.
- Frontier's technology platform – *Portfolio Analytics* has the modelling capability to simulate asset returns from established variables including expected return, risk and correlation between assets.
  - Define variables: Establish variables (return, risk and correlation) based on historical data.
  - Generate random returns: Use these variables to generate a series of random returns, assuming a normal distribution.
  - Run simulations: Repeat the process thousands or millions of times to create a distribution of possible future returns.
- As Chart 3 shows, portfolio outcomes vary greatly in different regimes, highlighting the importance of regime analysis.
  - The distribution of the DAA portfolio is slightly less dispersed compared to the SAA model portfolio as the DAA portfolio underweights risk assets.
  - In *Downturn deflation* the DAA distribution is less skewed to the left, showing some degree of downside protection in the DAA portfolio.
- Current simulations assumes each year are independent. We will be exploring the use of path dependency in the future.

Chart 3: Simulated portfolio return distribution by regime



Source: Datastream, Frontier Advisors

Simulation outcome

Accounting for asset returns under different macro environments changes portfolio modelling outcomes

Chart 4: Histogram of ten-year portfolio return (p.a.) – equilibrium assumptions

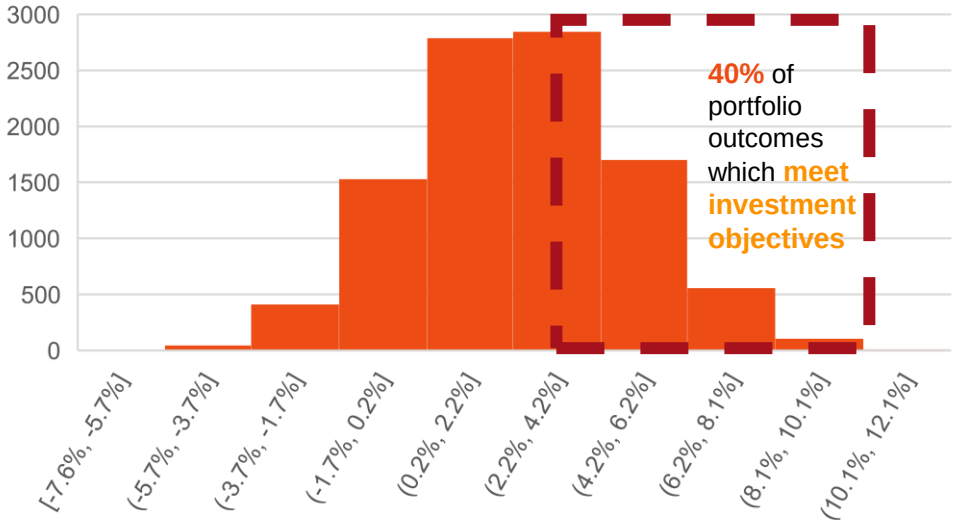
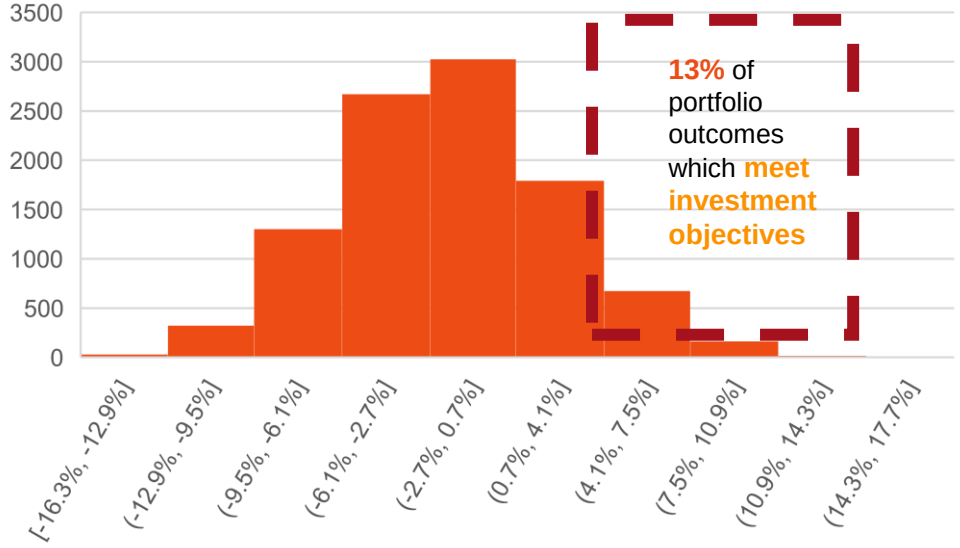


Chart 5: Histogram of ten-year portfolio return (p.a.) – regime pathway



Pathway: ST,ST,DD,DD,DD,DD,DD,N,N,N (ST=*Stagflation*, DD=*Downturn deflation*, N=*Normal*), used for demonstration purpose only.

- Charts 4 and 5 represent the modelled range of portfolio return outcomes. By factoring in potential shifts in the economic climate, we can observe a significant influence on the estimated likelihood of meeting portfolio objectives. This illustrates the importance of considering macroeconomic changes when estimating portfolio performance.
- Modelling the global economic downturn pathway changes the probability of achieving the portfolio objective from around 40% to less than 15%.

Enhanced portfolio modelling and risk management: Economic regime analysis allows clients to tailor simulations to their expectation of future economic conditions. This can assist with better understanding in potential portfolio performance and risk.

Tailored strategies and diversification: Integration of potential future economic outcomes may allow for development of tailored investment strategies, considering macroeconomic conditions, and diversify their portfolios effectively to reduce concentration risk.

Simulation outcome

Accounting for asset returns under different macro environments changes portfolio modelling outcomes

Chart 6: Histogram of ten-year portfolio return (p.a.) – equilibrium assumptions

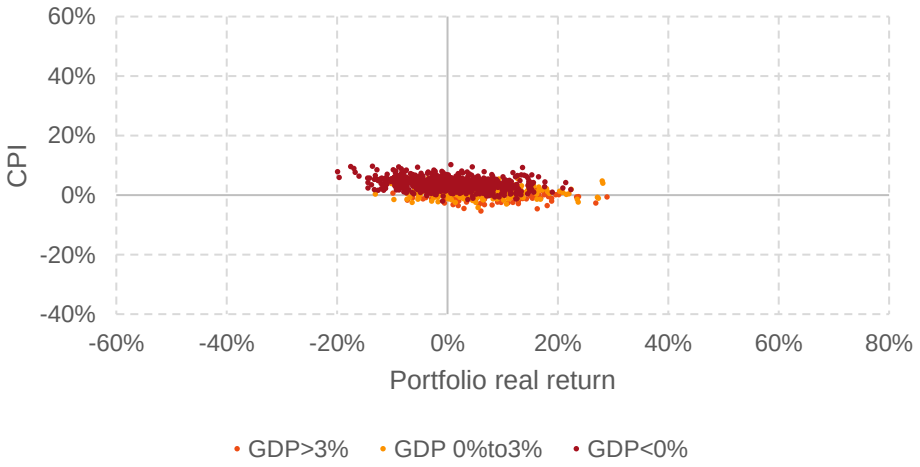
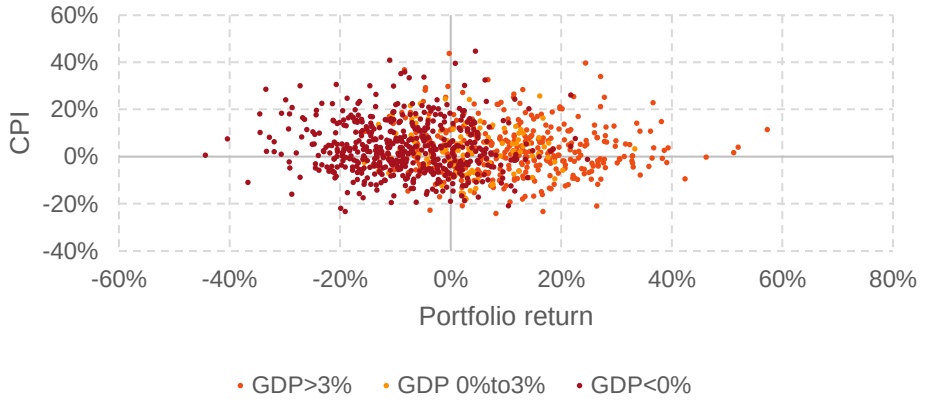


Chart 7: Histogram of ten-year portfolio return (p.a.) – regime pathway



Pathway: ST,ST,DD,DD,DD,DD,DD,N,N,N (ST=*Stagflation*, DD=*Downturn deflation*, N=*Normal*), used for demonstration purpose only.

- Charts 6 and 7 represent the spread of portfolio return outcomes against simulated levels of inflation. By including potential shifts in the economic environment, there is a significant impact on the level of concentration in portfolio returns. This illustrates the importance of considering macroeconomic changes when modelling portfolio return forecasts.
- The current portfolio simulation process operates on a static model, applying the same assumptions for each year of the simulation. This results in a constant pathway of returns throughout the entire simulation period.
- By incorporating a regime pathway, however, we can introduce variability in the assumptions utilised. This variation aligns with anticipated economic changes during the simulation period, thereby leading to fluctuations in return outcomes as the simulation adjusts between different assumptions. This approach provides a more realistic and dynamic perspective on portfolio performance over time.

Dynamic decision-making and scenario analysis: Simulations can be re-run as future expectations of economic conditions change. This can assist with dynamic and strategic decision-making.

Broader long-term planning: Clients can run multiple different scenarios over varying time periods to explore a range of implications of current and long-term portfolio allocations.

Conclusion

In this paper we developed a set of economic regimes that reflect the unique characteristics and risk profiles of various macroeconomic environments. The modelling outcome highlights that different economic regimes can lead to divergent returns across asset classes and alter their correlations. For example, during a recessionary regime, equity returns tend to be lower due to reduced corporate earnings and investor pessimism. Bonds, particularly government bonds, typically perform well as investors seek safer investments. The correlation between equities and bonds are negative most time but are often positive in high inflation regimes.

This regime modelling is available for clients interested in extended customised modelling, providing a comprehensive understanding of market dynamics and aiding in more informed decision-making. The current regime analysis is also set to expand to encompass more asset classes. Going forward, a dynamic regime shifting approach is proposed, potentially employing a stochastic process or pre-defined transitional probabilities, to replace the current static regime pathway, thus considering the transition process between different regimes and enhancing portfolio modelling accuracy over extended periods.

In conclusion, this framework provides more accurate predictions and better risk management for investments in different economic scenarios. This enhanced model equips clients with a more sophisticated understanding of how their portfolios may perform under varying economic conditions. It also allows for more accurate risk assessment, enabling more informed investment decisions.

Want to learn more?

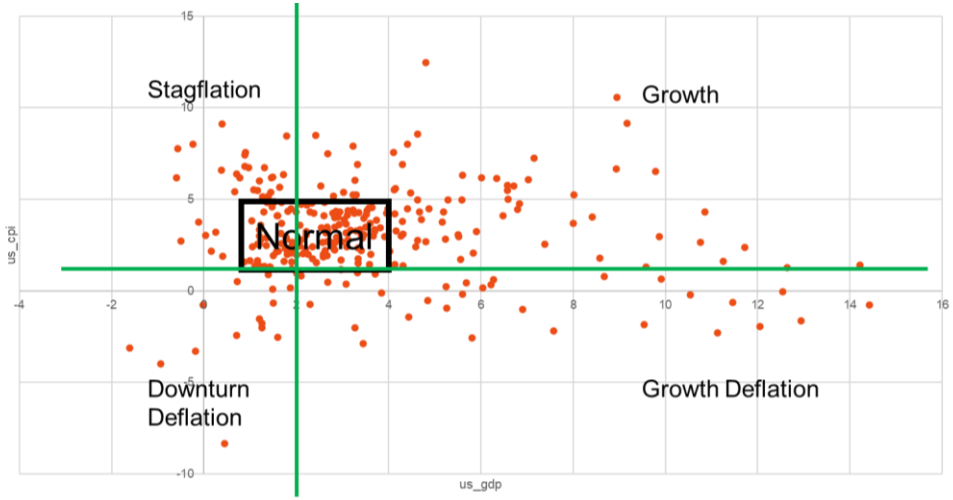
Please reach out to Frontier if you have any questions or visit frontieradvisors.com.au for more information.

Appendix

Regime classification approach 1 – economic factor stratification

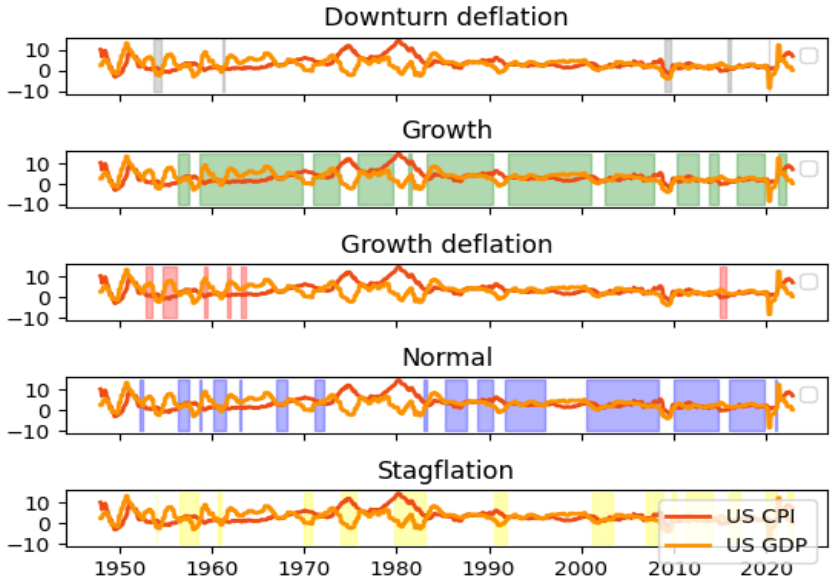
Grouping data based on GDP/CPI stratification

Exhibit 1: US GDP CPI Scatter plot



Source: Frontier Advisors, Datastream

Exhibit 2: Historical data grouped by scatterplot regimes



* Exhibit 1 plots quarterly yoy% US GDP against CPI values across 1951-2022. Each dot corresponds to one data point. The green lines are qualitatively assigned to define all other regimes except for *Normal. Normal* is formed based on the density of datapoints. In Exhibit 2 the shaded areas represent the periods that are classified as the given regime. Note: for analytical purpose the regimes have over-lapping periods in Exhibit 2, but in our final classification the regimes are classified as mutually exclusive.

- Two macro factors are considered as the defining elements of different regime states: growth and inflation, defined by Gross Domestic Product (GDP) growth and Consumer Price Index (CPI) respectively.
- The conditions of the macroeconomy can broadly be captured by using GDP growth (output) and inflation (change in price levels), making them two key characteristics of economic outcomes feeding into investment returns.
- Visualising the grouped data from the scatterplot on time-series charts allows for easy comparison across different regimes. As shown in Exhibit 2, consistent with the scatterplot, *Normal* and *Growth* cover most of the data points.

Regime classification approach 2 – continuous period analysis

Grouping data based on consecutive periods

Exhibit 3: Classification of consecutive historical periods

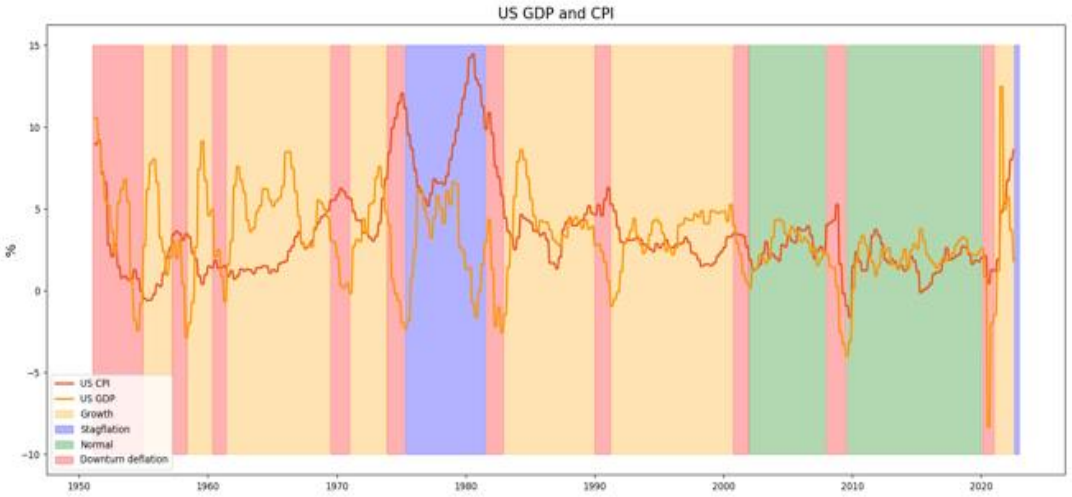
Key market cycles
PMI expansion/contraction
Fed Funds rate hiking cycles
US recession
US market crashes (peak to trough)
US CPI rising/falling
US GDP rising/falling
WW1 & WW2

→

Regimes
Recession
Normal
Downturn deflation
Stagflation

→

Exhibit 4: Regimes defined by grouping consecutive historical periods



The second approach specifically focuses on the time-series correlation in macroeconomic conditions between consecutive periods, differing from the first approach where each datapoint is treated as an independent observation.

- The implicit assumption in support of this approach is that the general market condition movements feature certain level of stickiness in time – regimes typically last a few years until the next significant market event or clear changes in key economic indicators.
- Only four of the five regime periods had been clearly historically defined, with no *Growth deflation* time periods identified.

A broad range of economic factors, world and market events were considered.

- The dates of occurrence were reviewed, collated and compared. This resulted in a large amount of period and date overlap. A combination of statistical summarisation techniques and qualitative oversight were applied to produce a set of mutually exclusive date periods.
- Each date period was then designated as being one of the four regimes, as specified in Exhibit 3.
- These date periods have then been collated to form four main datasets to allow for historic analysis incorporating a level of consecutive time period momentum (Exhibit 4).

Regime classification approach 3 – economic fundamental analysis

Looking for the most similar neighbour(s) in history to the current economic environment

This approach is leveraged on Frontier's 'economic distance model'. The model uses a selection of macroeconomic factors to measure the similarity of historic time periods (from an economic and market point of view) compared with a chosen economic environment.

This approach differs from the previous two approaches in that it considers multiple macro indicators other than GDP/CPI.

Exhibit 5: Chosen input variables

Economic cycle indicators	Market cycle indicators	Risk indicators
ISM inventory (six-month average)	Yield curve (10 less two-year US treasury yields)	VIX (replaced with S&P 500 composite index for
Fed funds rate	Credit spreads (YOY% change of BAA – AAA yields)	long-term data dated back to 1970, six-month average)
OECD leading indicator (YOY% change)		
Industrial production		
Debt/GDP		
Unemployment gap		
Oil price (YOY% change)		
CPI (YOY% change)		

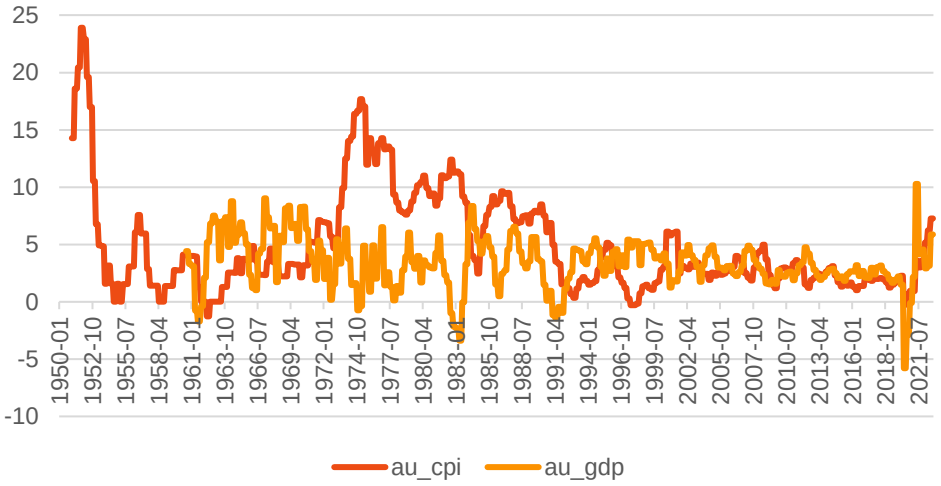
Frontier recently produced a paper outlining the economic distance model and how we use it to monitor the movements in macro environment. The paper is available upon request. Model set up:

- Step 1: Standardise input values for each indicator across the whole sample period.
- Step 2: Calculate the differences between a given period and all historical periods.
- Step 3: Transform the differences calculated in step 2 to distance scores, all distance scores range between [0,1]. The higher the score, the higher the similarity.

We designate an example period for each regime. Then the economic distance model looks for the top 10 closest historic points that have the highest similarity to the example periods. Historic periods that are classified as peers to the example period are then grouped together for each regime to calculate the asset distribution parameters. These parameters are then reviewed in comparison with the output from the other two approaches to form the asset class assumptions under each regime.

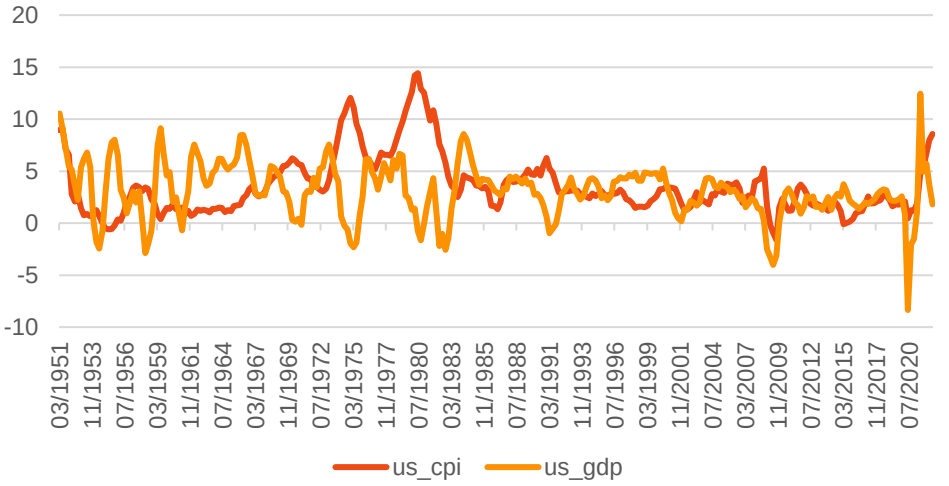
US and Australian GDP and CPI

Exhibit 6: AU GDP & CPI



Source: Macrobond

Exhibit 7: US GDP & CPI



Source: Macrobond

Historically Australian GDP and CPI values are quite close to US levels. Domestic economic growth tends to be lower in *Growth* compared to US and inflation level also lower. In *Downturn deflation* domestic growth rate tend to slow down more significantly than US and in *Stagflation* domestic inflation level tends to be higher.

Based on the outcome from US and Australian regimes, the relative performance of domestic assets aligns well with international assets: equity, infrastructure and property perform the best in *Growth* and tend to struggle in *Downturn deflation* and *Stagflation*. Bonds tend to outperform in high-risk environment, likely reflecting the safe-haven effect. Due to the broad resemblance in asset returns, it is a reasonable simplification to assume interchangeable US and Australian regimes.

Differentiated regime assumptions by region is a potential extension of the research that could be considered further in the future.

Distributions by regimes

Different regimes result in different modelled return distribution

Exhibit 8: Distribution of different asset classes in different regimes

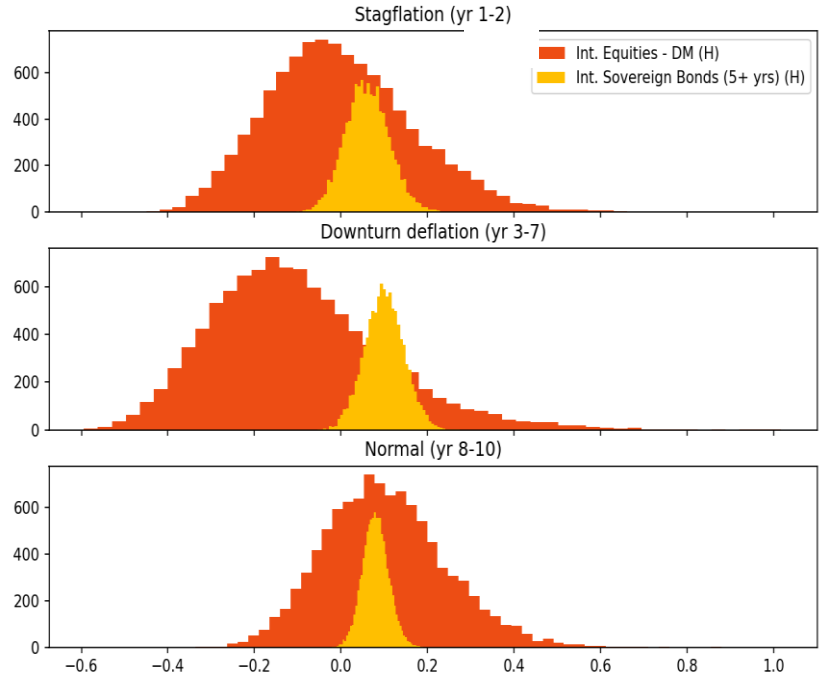
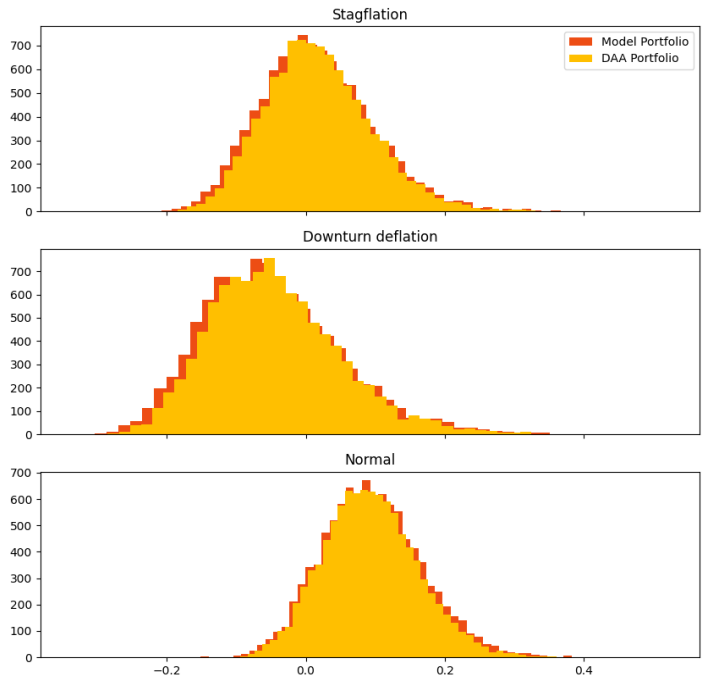


Exhibit 9: Distribution of model portfolio in different regimes



- Equities exhibit a wider spread than bonds. The divergence between bond and equity is the most salient in *Downturn deflations*.
- The return distribution of the model portfolio resembles the developed market equities return distribution on the left, showing similar skew especially in the downturn deflation regime but it is less dispersed along the x-axis. This is likely because the model portfolio has a large weight to developed market equities. The model portfolio does have fewer extreme outcomes though given it is a diversified portfolio.
- The return distribution of the DAA model portfolio is slightly less dispersed compared to the SAA model portfolio due to a lower allocation to risk assets. Compared to the SAA model portfolio, the DAA model portfolio has higher infrastructure, higher cash, lower equities, lower property and lower alternative debt.

Simulation approach

Following a regime pathway no longer assumes fixed asset class returns throughout time

Exhibit 10: Example regime pathway

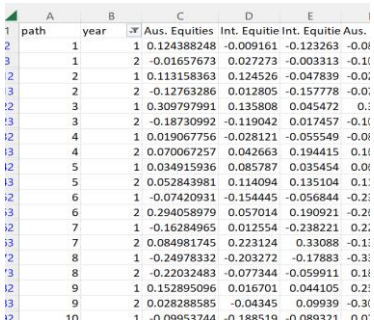
	Year 1-2	Year 3-7	Year 8-10
Regime	Stagflation	Downturn deflation	Normal

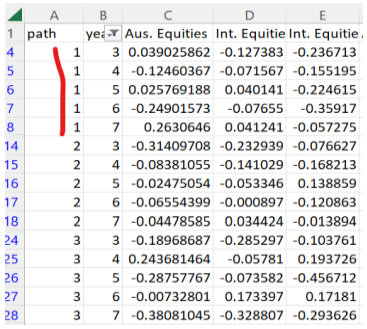
- Stagflation assumption
- 2 years, 10000 paths
- 16 assets + 2 macro factors

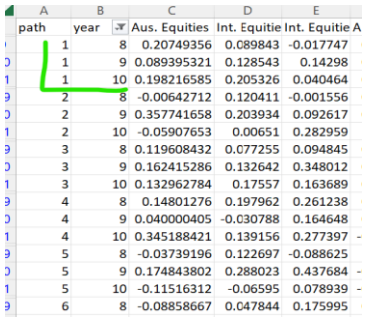
- Downturn deflation assumption
- 5 years, 10000 paths
- 16 assets + 2 macro factors

- Normal assumption
- 3 years, 10000 paths
- 16 assets + 2 macro factors

Monte Carlo Simulation Engine

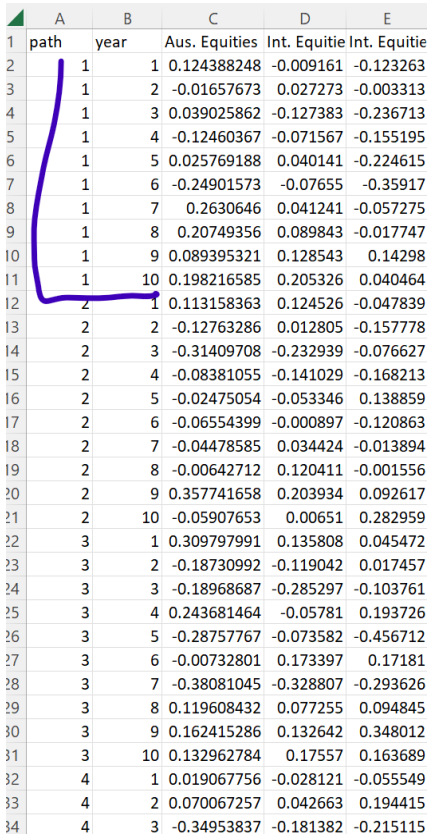






Stacking outputs

Simulation outputs



	A	B	C	D	E
1	path	year	Aus. Equities	Int. Equitie	Int. Equitie
2	1	1	0.124388248	-0.009161	-0.123263
3	1	2	-0.01657673	0.027273	-0.003313
4	1	3	0.039025862	-0.127383	-0.236713
5	1	4	-0.12460367	-0.071567	-0.155195
6	1	5	0.025769188	0.040141	-0.224615
7	1	6	-0.24901573	-0.07655	-0.35917
8	1	7	0.2630646	0.041241	-0.057275
9	1	8	0.20749356	0.089843	-0.017747
10	1	9	0.089395321	0.128543	0.14298
11	1	10	0.198216585	0.205326	0.040464
12	2	1	0.113158363	0.124526	-0.047839
13	2	2	-0.12763286	0.012805	-0.157778
14	2	3	-0.31409708	-0.232939	-0.076627
15	2	4	-0.08381055	-0.141029	-0.168213
16	2	5	-0.02475054	-0.053346	0.138859
17	2	6	-0.06554399	-0.000897	-0.120863
18	2	7	-0.04478585	0.034424	-0.013894
19	2	8	-0.00642712	0.120411	-0.001556
20	2	9	0.357741658	0.203934	0.092617
21	2	10	-0.05907653	0.00651	0.282959
22	3	1	0.309797991	0.135808	0.045472
23	3	2	-0.18730992	-0.119042	0.017457
24	3	3	-0.18968687	-0.285297	-0.103761
25	3	4	0.243681464	-0.05781	0.193726
26	3	5	-0.28757767	-0.073582	-0.456712
27	3	6	-0.00732801	0.173397	0.17181
28	3	7	-0.38081045	-0.328807	-0.293626
29	3	8	0.119608432	0.077255	0.094845
30	3	9	0.162415286	0.132642	0.348012
31	3	10	0.132962784	0.17557	0.163689
32	4	1	0.019067756	-0.028121	-0.055549
33	4	2	0.070067257	0.042663	0.194415
34	4	3	-0.34953837	-0.181382	-0.215115

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